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Sphaleron in the Dilatonic Gauge Field Theory

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Abstract

Motivated by the Kaluza-Klein theory with a large number of extra spacetime dimensions, we present a numerical study of static, spherically symmetric sphaleron solutions coupled to the dilaton fields. We show that sphalerons may have different dilaton cloud configurations, resulting in new massive sphalerons, in general. However, there exist different cloud configurations with different values of the dilaton mass.

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1 INTRODUCTION

Recently there has been a considerable interest in the field theories with large number of extra spacetime dimensions. In comparison to the standard Kaluza-Klein theory these extra dimensions may be restricted only to the gravity sector of the theory while the Standard Model (SM) fields are assumed to be localized on the 4-dimensional spacetime [1-3]. It is a promising scenario from the phenomenological point of view because it shifts the energy scale of unification from $10^{19}\, GeV$ down to $10 - 100\, TeV$.

The gauge field theory is extended by inclusion of the dilatonic field in such theories. Such fields appear also in a natural way in the Kaluza-Klein theories [4], superstring inspired theories [5, 6] and in theories based on the non-commutative geometry approach [7].

As previous studies have already shown the inclusion of dilatons in a pure Yang - Mills theory has consequences already at the classical level. In particular, the dilaton Yang - Mills theories possess 'particle - like' solutions with finite energy which are absent in pure Yang - Mills case.

On the other hand, the sphaleron was introduced by Klinkhamer and Manton [8] to describe a static electroweak gauge - field configuration that constitutes a saddle point between two vacua, differing from one another by non trivial topology (the hedgehog topology).

Analogous equations have recently been obtained for the 't Hooft - Polyakov monopole model coupled to the dilatonic field [9]. There is also growing interest [10] in baryon number violation within the Standard Model induced by sphalerons. The rate of baryon number violating processes depends on the energy of the sphaleron [11].

The aim of this paper is to examine the properties of the sphaleron solution in the presence of a dilatonic field, in the electroweak theory. We shall demonstrate below the existence of spherically symmetric dilatonic clouds surrounding the sphalerons with interesting implications.

2 THE DILATONIC GAUGE FIELD THEORY

Dilatons appear in the higher dimensional theory after the process of compactification. To illustrate the point, we consider six-dimensional Kaluza - Klein theory.

Let us now consider the action integral of Einstein-Yang-Mills-Higgs theory in the six-dimensional spacetime:

$$\mathcal{S} = \int d^6x \sqrt{-g_6} L, \tag{1}$$

where $g_6 = det(g_{MN})$ and $M = \{\mu, i\}$, $N = \{\nu, j\}$ with $x^M = \{x^\mu, y^i\}$, $i = 1, 2$. The metrical tensor in the six-dimensional spacetime can be written:

$$g_{MN} = \begin{pmatrix} e^{-2\xi(x)/f_0}\overline{g}_{\mu\nu} & 0 \\ 0 & -\delta_{ij}e^{+2\xi(x)/f_0} \end{pmatrix}, \tag{2}$$

where f_0 is an arbitrary constant. According to the above definition we can write:

$$\sqrt{-g_6} = \sqrt{-\overline{g}} e^{-2\xi(x)/f_0}. \tag{3}$$

In equation (2)

$$g_{\mu\nu} = e^{-2\xi(x)/f_0} \overline{g}_{\mu\nu} \tag{4}$$

represents the four-dimensional metric in the Jordan frame, while $\overline{g}_{\mu\nu}$ refers the Einstein frame. Fluctuations around the four-dimensional Minkowski

$$\overline{g}_{\mu\nu} = \eta_{\mu\nu} + h_{\mu\nu}(x, y) \tag{5}$$

will produce the interaction with Kaluza-Klein dilatons

$$h_{\mu\nu}(x, y) = \sum_{\mathbf{n}} h^{\mathbf{n}}_{\mu\nu}(x) e^{i\frac{2\pi n^i y^i}{r_2}} \tag{6}$$

with the typical mass scale M (for $n^i \neq 0$).

We consider here the Lagrangian of the Einstein-Yang-Mills-Higgs field as follows:

$$L = L_g + L_{SM}\delta(y), \tag{7}$$

$$L_g = -\tfrac{1}{2\kappa_6} R, \tag{8}$$

$$L_{SM} = -\tfrac{1}{4} F^a_{MN} F^{aMN} + D_M H^+ D^M H - U(H), \tag{9}$$

where κ_6 is the six-dimensional gravitional coupling and

$$U(H) = \lambda \left(H^+ H - \frac{1}{2} v_0^2 \right)^2. \tag{10}$$

R is a curvature scalar defined as usual:

$$R = g^{MN} R_{MN}, \tag{11}$$

and R_{MN} is the Ricci tensor:

$$R_{MN} = \partial_L \Gamma^L_{MN} - \partial_N \Gamma^L_{ML} + \Gamma^L_{MN} \Gamma^R_{LR} - \Gamma^R_{ML} \Gamma^L_{NR}. \tag{12}$$

Γ^L_{MN} - are the six-dimensional Christoffel symbols. Let us compactify the six-dimensional spacetime to the four-dimensional Minkowski one on the torus ($\mathcal{M}_6 \to \mathcal{M}_4 \times \mathcal{S}^1 \times \mathcal{S}^1$). In this paper we assume that the extra dimensions are compactified to a two-dimensional torus with a single radius r_2. For the four-dimensional Minkowski spacetime ($\overline{g}_{\mu\nu} = \eta_{\mu\nu}$)

$$R = \frac{4}{f_0^2} e^{2\xi(x)/f_0} \{ -\partial_\mu \xi \partial^\mu \xi + f_0 \partial_\mu \partial^\mu \xi \}. \tag{13}$$

The six-dimensional action may be rewritten as:

$$\mathcal{S} = \int d^4x \int d^2y \sqrt{-g_6} L = \int d^4x \sqrt{-\overline{g}} \mathcal{L}, \tag{14}$$

where $\int d^2y = (2\pi r_2)^2$ and $\mathcal{L}$ is the effective Lagrange function in four-dimensional spacetime. The six-dimensional gravitional coupling $\kappa_6 = 8\pi G_6$ is convenient to define as

$$G_6^{-1} = \frac{4\pi}{(2\pi)^2} M^4,$$

where M is the energy scale of the compactification ($\sim 10 - 100\, TeV$). The cosmological consideration [12] gives the bound $M > 100\, TeV$ which corresponds to $r_2 < 5.1\, 10^{-5}\, mm$. By denoting the four-dimensional coupling constant $\kappa = 8\pi G_N = 8\pi M_{Pl}^{-2}$, we get

$$M_{Pl}^2 = 4\pi M^4 r_2^2. \tag{15}$$

The parameter f_0 is determinated by the Planck mass:

$$f_0^2 = 2M^4 r_2^2 = \frac{1}{2\pi} M_{Pl}^2 \tag{16}$$

so as to produce the 1/2 term for the dilaton field in (19). At present we have

$$f_0 = \frac{1}{\sqrt{2\pi}} M_{Pl} \sim 4.87\, 10^{18}\, GeV/c^2, \tag{17}$$

but here the Planck mass M_{Pl} is no longer a fundamental constant, it may change during the evolution of the universe [13]. Cosmological considerations [13] suggest that in the early universe the internal radius r_2 was smaller ($r_2(t) = b(t) r_2$ where $b(t)$ is the radion field). As a result, the Planck mass M_{Pl} was smaller in the early universe, and the gravitational interaction bigger than at the present time. An estimation [13] of the Planck mass in the early universe gives

$$M_{Pl,0} \approx 10^{-11}\, M_{Pl} \sim 10^8\, GeV.$$

This also leads to a lowering of the f_0.

As a result of compactification of the six-dimensional Lagrangian, we get the following Lagrangian for the Yang-Mills-Higgs fields :

$$\mathcal{L}_{SM} = (D_\mu H)^+ D^\mu H - e^{-\frac{2\xi(x)}{f_0}} U(H) - \frac{1}{4} e^{\frac{2\xi(x)}{f_0}} F^a_{\mu\nu} F^{a\mu\nu} + .. \tag{18}$$

and

$$\mathcal{L}_g = \frac{1}{2} \partial_\mu \xi(x) \partial^\mu \xi(x) + ... \tag{19}$$

for gravity.

In this paper we shall focus on the electroweak theory with the gauge field extended by adding the dilatonic field. One of the interesting features of the Standard Model, with $SU_L(2) \times U_Y(1)$ symmetry, is the classical scale invariance

of the highly symmetric phase. Then, the anomalous symmetry and quantum effects cause its break up, and produce nonvanishing cosmological constant. The classical scale invariance offers a link between the Standard Model and gravity. The Jordan-Brans-Dicke theory [14] of the scalar-tensor theory of gravity is an example of successful implementation of this idea.

The Glashow-Weinberg-Salam dilatonic model with $SU_L(2) \times U_Y(1)$ symmetry is described by the Lagrangian

$$\begin{aligned}\mathcal{L}_B &= -\frac{1}{4}e^{2\xi(x)/f_0}F^a_{\mu\nu}F^{a\mu\nu} - \frac{1}{4}e^{2\xi(x)/f_0}B_{\mu\nu}B^{\mu\nu} + \\ &\quad \frac{1}{2}\partial_\mu\xi(x)\partial^\mu\xi(x) + (D_\mu H)^+ D^\mu H - U(H)e^{-2\xi(x)/f_0}\end{aligned} \tag{20}$$

with the $SU_L(2)$ field strength tensor $F^a_{\mu\nu} = \partial_\mu W^a_\nu - \partial_\nu W^a_\mu + g\epsilon_{abc}W^b_\mu W^{c\nu}$ and the $U_Y(1)$ field tensor $B_{\mu\nu} = \partial_\mu B_\nu - \partial_\nu B_\mu$. Dilaton fields increase the participation of the gauge fields in the Standard Model and change the Higgs potential into:

$$-\frac{1}{4}F^a_{\mu\nu}F^{a\mu\nu} \to -\frac{1}{4}e^{2\xi(x)/f_0}F^a_{\mu\nu}F^{a\mu\nu}, \tag{21}$$

$$U(H) \to U(H)e^{-2\xi(x)/f_0}. \tag{22}$$

The covariant derivative is given by $D_\mu = \partial_\mu - \frac{1}{2}igW^a_\mu\sigma^a - \frac{1}{2}g^{'}YB_\mu$, where B_μ and $W_\mu = \frac{1}{2}W^a_\mu\sigma^a$ are local gauge fields associated with $U_Y(1)$ and $SU_L(2)$ symmetry groups, respectively. Y denotes the hypercharge, as before. The gauge group is a simple product of $U(1)_Y$ and $SU(2)_L$, hence we have two gauge couplings g and g'. The generators of gauge groups are represented by the unit matrix for $U_Y(1)$ and Pauli matrices for $SU_L(2)$. In the simplest version of the Standard Model a doublet of Higgs fields is introduced as $H = \begin{pmatrix} H^+ \\ H^0 \end{pmatrix}$, with the Higgs potential:

$$U(H) = \lambda\left(H^+H - \frac{1}{2}v^2\right)^2 e^{-2\xi(x)/f_0}. \tag{23}$$

The dilaton fields change the scale of the interacting constant λ, thus the mass of Higgs bosons is changed; but the scale of the spontaneous breaking v is not altered. The f_0 parameter in the Lagrange function (20) determines the dilaton scale. At the present time f_0 is rather high (17), so the interaction with dilatons can be neglected. However, in the early universe when the Planck mass M_{Pl} was smaller (for details see [13]) the value of the f_0 was smaller, as well. For that reason we choose the intermediate scale $f_0 = 10^7\ GeV$, and the electroweak symmetry breaking scale $v = 246\ GeV$. The form of the potential (23) leads to a vacuum degeneracy, leading to the presence of the nonvanishing vacuum expectation value of the Higgs field, and consequently to the presence of fermion and boson masses. In the spontaneous symmetry breaking process, the Higgs field also acquires nonzero mass.

The Euler-Lagrange equations for the Lagrangian (20) are scale - invariant:

$$x^\mu \to x'^\mu = e^{\frac{u}{f_0}} x^\mu, \tag{24}$$

$$\xi \to \xi' = \xi + u, \tag{25}$$

$$H \to H' = H, \tag{26}$$

$$W_\mu^a \to W_\mu^{;a} = e^{-\frac{u}{f_0}} W_\mu^a, \tag{27}$$

$$B_\mu \to B'_\mu = e^{-\frac{u}{f_0}} B_\mu. \tag{28}$$

These transformations change the Lagrange function in the following way:

$$\mathcal{L} \to \mathcal{L}' = e^{-\frac{2u}{f_0}} \mathcal{L}. \tag{29}$$

This symmetry can be formulated equivalently as a scaling symmetry on the coordinates, and the dilaton is often denoted as a Goldstone boson for dilatation. The origin of the symmetry of the equations of motion is easily understood from the Kaluza–Klein origin of the action. The scale transformations are equivalent to a rescaling of the internal dimensions.

3 THE DILATONIC SPHALERON

The dilatonic solutions in the gravity and the gauge field theory are a subject of growing interest [9]. Let us now consider the sphaleron type solution in the electroweak theory with dilatons. The sphaleron may be interpreted as inhomogeneous spherical topological solutions of the motion equations in the Standard Model. We can assume, for simplicity, that $g' = 0$ [15].
Now, let us make the ansatz for the sphaleron Higgs field:

$$H = \frac{1}{\sqrt{2}} v U(x) h(r) \begin{pmatrix} 0 \\ 1 \end{pmatrix}, \tag{30}$$

where $U(x) = i \sum \sigma^a n^a$ and $n^a = \frac{r^a}{r}$ describe the 'hedgehog' structure. This produces a nontrivial topological charge of the sphaleron. The topological charge is equal to the Chern-Simons number. Such a 'hedgehog' structure determines the asymptotic shape of the sphaleron with gauge fields different from zero:

$$W_i^a = \epsilon_{aij} n^j \frac{1 - f(r)}{gr}, \quad W_0^a = 0. \tag{31}$$

We can define the dilatonic field:

$$\xi(x) = f_0 s(x). \tag{32}$$

Let us introduce the dimensionless variable x, defined as $x = gvr = 2M_W r = 2r/r_W$, where $M_W = \frac{1}{2}gv \sim 80\ \ GeV$, $r_W = \frac{1}{M_W} \sim 10^{-3} fm$. The spherical symmetry is assumed for the dilaton field $s(x)$ as well as for the Higgs field $h(x)$ and the gauge field $f(x)$, resulting in the following expression for the total energy:

$$E = \frac{4\pi v}{g} \int \rho_0(x) x^2 dx, \tag{33}$$

where the energy density is:

$$\begin{aligned} \rho_0(x) \quad &= \quad \frac{1}{2}h'(x)^2 + \frac{1}{2}\beta s'(x)^2 + \frac{1}{x^2}e^{2s(x)}\left\{f'(x)^2 + \frac{1}{2x^2}(f(x)-1)^2(f(x)-3)^2\right\} \\ &+ \quad \frac{1}{4}\varepsilon\left(h(x)^2-1\right)^2 e^{-2s(x)} + \frac{1}{4x^2}(f(x)-3)^2 h(x)^2. \end{aligned} \tag{34}$$

$M_H^2 = 2\lambda v^2$ determines the Higgs mass;

$$\beta = \frac{f_0^2}{v^2} = \frac{2M^4 r_2^2}{v^2} \sim 10^9$$

and $\varepsilon = \frac{M_H^2}{2M_W^2} \sim\ 1.152$ (for the Higgs mass $M_H \sim 120$ GeV) is a dimensionless parameter which determines the sphaleron system completely. As a result, the Euler-Lagrange equations are:

$$\begin{aligned} f''(x) \quad &+ \quad 2f'(x)s'(x) + \frac{1}{4}(3-f(x))h(x)^2 e^{-2s(x)} \\ &- \quad \frac{1}{x^2}(f(x)-1)(f(x)-2)(f(x)-3) = 0; \end{aligned} \tag{35}$$

the $f(x)$ function describes the gauge field inside the sphaleron, and the $h(x)$ function describes the Higgs field in our theory. The last one satisfies the following equation:

$$h''(x) + \frac{2}{x}h'(x) + \varepsilon e^{-2s(x)}(1-h^2(x))h(x) - \frac{1}{2x^2}(3-f(x))^2 h(x) = 0. \tag{36}$$

The $s(x)$ function describes the dependence of the dilaton field on x in the extended electroweak theory and obeys the equation:

$$\begin{aligned} s''(x) \quad &+\tfrac{2}{x}s'(x) + \tfrac{e^{2s(x)}}{\beta}\left\{-\tfrac{2}{x^2}f'(x)^2 - \tfrac{1}{x^4}(f(x)-1)^2(f(x)-3)^2\right\} \\ &+\tfrac{\varepsilon}{2\beta}e^{-2s(x)}(1-h^2(x))^2 = 0. \end{aligned} \tag{37}$$

The simplest solutions are global and correspond to the vacuum with the broken symmetry in the Standard Model. It is obvious that far from the center of the sphaleron our solutions should describe the broken phase which, is very well known from the Standard Model. We can find easily the asymptotic solutions for $x \to 0$:

$$f(x) = 1 + 2rx^2 + O(x^3), \tag{38}$$

$$h(x) = ux + O(x^3), \tag{39}$$

$$s(x) = (a + s_\infty - awx^2) + O(x^3), \tag{40}$$

and for $x \to \infty$:

$$f(x) = 3 - f_\infty e^{-x}, \tag{41}$$

$$h(x) = 1 - \frac{h_\infty}{x} e^{-\sqrt{2\epsilon}}, \tag{42}$$

$$s(x) = s_\infty - \frac{d_\infty}{x}. \tag{43}$$

We make an ansatz for the trial functions as:

$$f(x) = 1 + 2\tanh^2(\sqrt{r}x) \sim 1 + 2rx^2 - \frac{4r^2x^4}{3} + O(x^5), \tag{44}$$

$$h(x) = \tanh(ux) \sim ux - \frac{u^3x^3}{3} + O(x^5), \tag{45}$$

where u, r are parameters. The variational method is based on trial functions depending on two parameters, u and r. We can find the E total energy dependence on the u, r parameters, for the sphaleron, (see the Fig.1).

We then get the minimum energy for u_0, and r_0. The trial functions for these parameters (u_0, r_0) give us initial data for the numerical solutions. So, we have the trial functions (solid lines in the Fig.1) and the numerical solutions (dashed lines) from the initial conditions obtained. We use the Runge-Kutta method (the shooting method [16]) for our numerical calculation. The trial functions are used to find the initial data close to zero, if x goes to zero (x_0), and far from zero, if x goes to infinity (x_∞). We start from x_0 and x_∞, and get two solutions. Then we glue them together. If the numerical method is correct then both of the numerical solutions should cover each other. We obtain such results for the gauge field, (see the Fig.3) and for the Higgs field, (see the Fig.4).

It is also very interesting to find the sphaleron mass dependence on the Higgs mass, (see the Fig.2). The rest mass of a sphaleron (without dilatons) is rather large (for our parameters):

$$(M_{sph} \sim E = 10.006\ TeV).$$

The sphaleron remains a bubble of the old high temperature phase. We construct also a trial function for the dilaton field:

$$s(x) = s_\infty + ae^{-wx^2}, \tag{46}$$

where w and a are parameters. We solve the set of the differential equations (35 -37) using the trial functions (44 - 46), which provide the initial conditions for a numerical estimate. The method of calculation is the same as for the

sphaleron without dilatons. For the dilatonic sphaleron, we can also find the E total energy dependence on the a parameter, (see the Fig.5).

The minimum energy we get for $a_0 = -0.384$ (with the same parameters as before). The mass of the dilatonic sphaleron is decreased, as follows:

$$M_{dil.sph} \sim E_d = 7.917 \;\; TeV. \tag{47}$$

The trial functions at these parameters give us the initial conditions for the numerical solutions. So, we have the trial functions (solid lines), and the numerical solutions (dashed lines) in the Fig. 5. The trial functions are used to find the initial data close to zero, and far from zero. We get two solutions, again. Then we glue them together. Both numerical solutions cover each other. We present the cases for the gauge field, (see the Fig.7) and for the Higgs field, (see the Fig.8).

With respect to the dilatation symmetry of the dilaton field we can shift the dilaton field and require its vanishing in the infinity. The numerical solution is stable for the dilatonic field all over the range of x, (see the dashed line in the Fig.9). The numerical solutions of the coupled system of the differential equations are close to our trial functions.

We have also found another local minimum for $a > 0$, (see the Fig.6). We see that it is very close to the sphaleron configuration without dilatons. These solutions differ from one another in the dilatonic cloud.

In the first solution (if $a_0 = -0.384 < 0$) the Higgs field is amplified (the dilaton field causes the increase of the energy of the Higgs field) and the gauge field is suppressed (the dilaton field reduces the energy of the gauge field) in the sphaleron. In the second solution (if $a > 0$) we have the reverse.

4 CONCLUSIONS

Numerical solutions suggest that the sphaleron possesses an 'onion-like' structure. In the small inner core, the scalar field decreases, with global gauge symmetry restoration $SU(2) \times U(1)$. In the middle layer, the gauge field undergoes sudden change. It is very interesting that the sphaleron coupled to the dilaton field has also an outer shell, where the dilaton field changes drastically. Our solutions describe the shapes of Higgs field and gauge field inside the sphaleron, as well as the change of the dilaton cloud surrounding the sphaleron. Such a cloud is large and extends far outside the sphaleron [17]. The sphalerons might be created during the first order phase transition in the expanding universe. The bubbles left after the phase transition could break the CP and C symmetry on their walls and could cause the breaking of the baryonic symmetry. Further increase of the energy of the dilaton fields causes the increase of the energy (mass) of the sphaleron. However, a decrease of the energy of the sphaleron causes the increase of the tunneling probability to the new nontrivial configuration. This effect generates the increase of the probability of baryogenesis [18]. With the sphalerons, the gauge field and the Higgs field configurations are very

similar to the configurations of the same fields without dilatons. Comparing the three Figs. 7, 8, 9 we can conclude that the dilatonic area is much bigger than the area of the change of the gauge field and the Higgs field. The conclusion drawn is that the dilaton field in general causes the increase of the mass of the sphaleron. However, there exists a minimal configuration at which the energy of the sphaleron is decreased. A sphaleron is said to be concentric with the following configuration: the Higgs field and the gauge field are embedded in the dilaton cloud; close to the center there is a change of the Higgs field, and then a change of the gauge field, both of them penetrated by a change of the dilaton field [17]. Now, we can see that dilatons have a small influence the Higgs field and the gauge field configurations. That means that a topological 'hedgehog' structure of the sphaleron is not modified. The sphaleron properties depend strongly on the dilaton field which appears from more dimensional spacetime compactification.

However, in the theories inspired by the Kaluza-Klein theory with large extra dimensions, new interactions with massive ($\sim M$) Kaluza-Klein gravitons also take place. Due to the topological charge, the sphaleron solutions are stable in the four-dimensional spacetime. The interactions with Kaluza-Klein gravitons $h^{\mathbf{n}}_{\mu\nu}(x)$ may cause the disintegration of the sphaleron.

There are also interesting spherically symmetric dilaton solutions coupled to the gauge field in the monopole case [19] and they may influence the monopole catalysis of baryogenesis.

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FIGURES

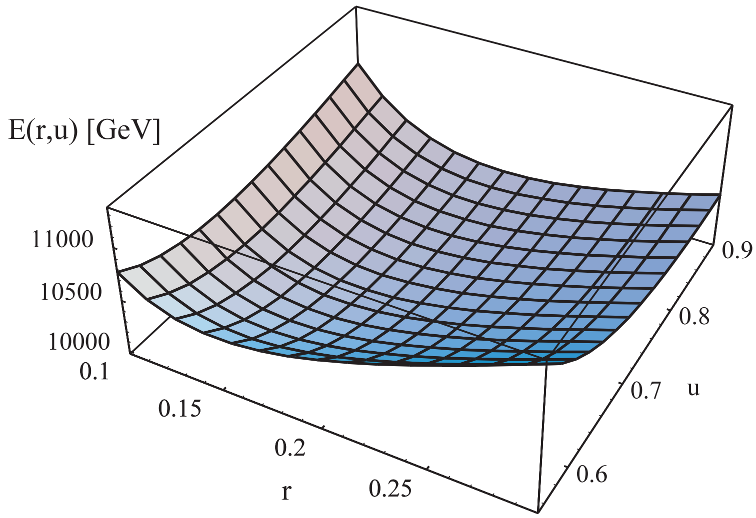

Figure 1: The total energy of the sphaleron in the standard model at the parameters ($\varepsilon = 1.152$, $M_H = 120$ GeV); the minimum energy (E(r,u) $=$ 10 006 GeV) is for the values: $r = 0.1735$, $u = 0.7586$.

Figure captions

Figure 1. The total energy of the sphaleron in the standard model at the parameters ($\varepsilon = 1.152$, $M_H = 120$ GeV); the minimum energy (E(r,u) $=$ 10 006 GeV) is for the values: $r = 0.1735$, $u = 0.7586$.
Figure 2. The dependence of the mass of the sphaleron on the Higgs mass (M_H).
Figure 3. The dependence of the gauge field of the dilatonic sphaleron on x, at the parameters $r = 0.2950$, $u = 0.9862$, $a = -0.3540$, $w = 2.47\ 10^{-8}$.
Figure 4. The dependence of the Higgs field of the dilatonic sphaleron on x, at the parameters $r = 0.2950$, $u = 0.9862$, $a = -0.3540$, $w = 2.47\ 10^{-8}$
Figure 5. The dependence of the mass of the dilatonic sphaleron on a parameter ($a < 0$), at the parameters: $r = 0.2958$, $u = 0.9862$, $w = 2.47\ 10^{-8}$. The minimum is for: $a = -0.3540$, $M(a) = 7917.36$ GeV.
Figure 6. The dependence of the mass of the dilatonic sphaleron on a parameter ($a > 0$), at the parameters: $r = 0.2958$, $u = 0.9862$, $w = 2.47\ 10^{-8}$
Figure 7. The dependence of the gauge field of the dilatonic sphaleron on x, at the parameters $r = 0.2950$, $u = 0.9862$, $a = -0.3540$, $w = 2.47\ 10^{-8}$.
Figure 8. The dependence of the Higgs field of the dilatonic sphaleron on x, at the parameters $r = 0.2950$, $u = 0.9862$, $a = -0.3540$, $w = 2.47\ 10^{-8}$.
Figure 9. The dependence of the dilaton field on x, at the parameters $r = 0.2777$, $u = 0.9862$, $a = -0.3540$, $w = 2.47\ 10^{-8}$.

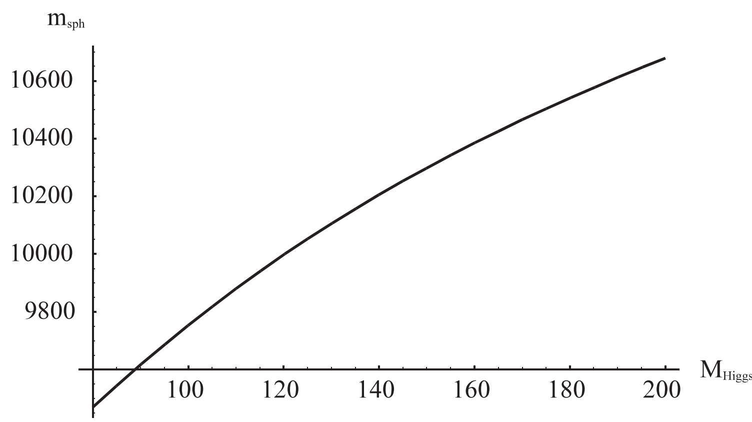

Figure 2: The dependence of the mass of the sphaleron on the Higgs mass (M_H).

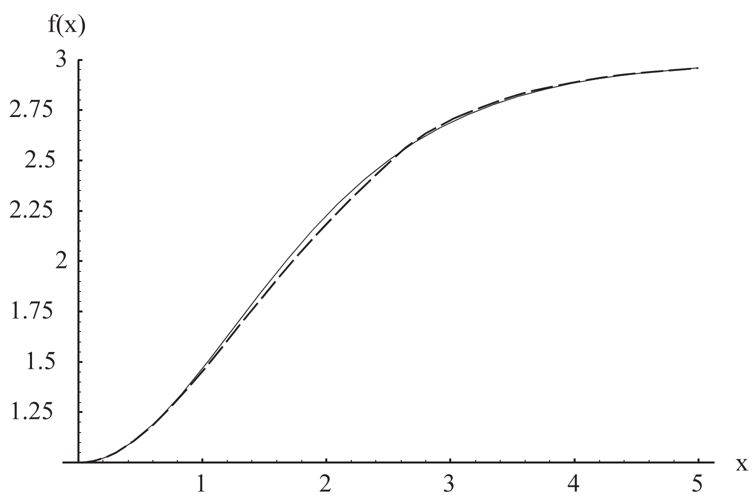

Figure 3: The dependence of the gauge field of the sphaleron on x, at the parameters $r = 0.2777$, $u = 0.8193$.

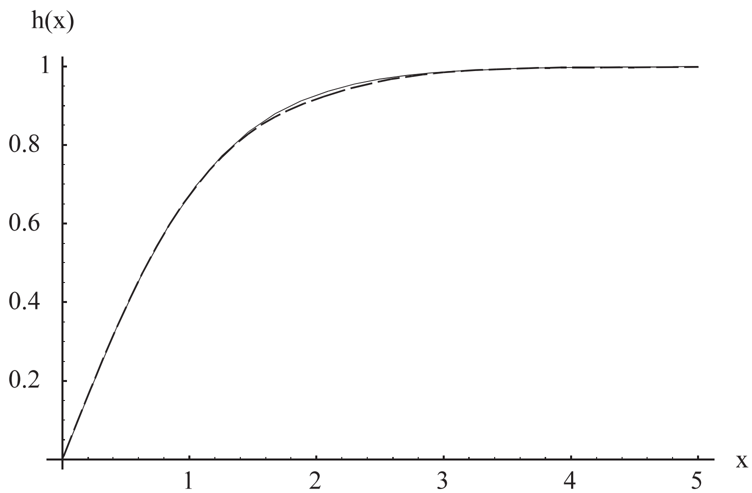

Figure 4: The dependence of the Higgs field of the sphaleron on x, at the parameters $r = 0.2777$, $u = 0.8193$.

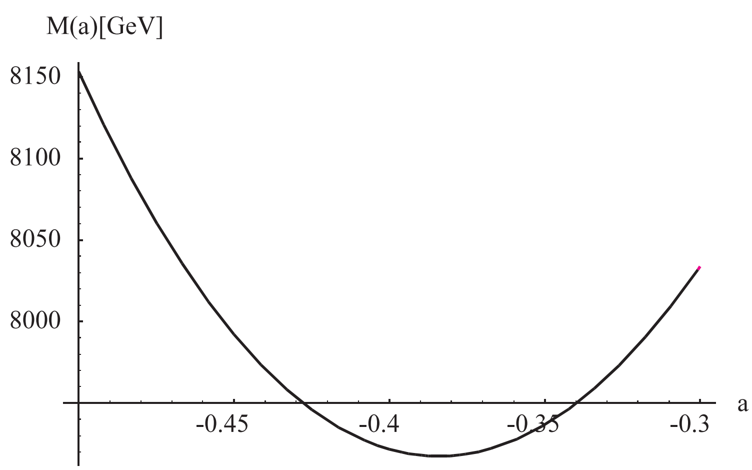

Figure 5: The dependence of the mass of the dilatonic sphaleron on a parameter ($a < 0$), at the parameters: $r = 0.2958$, $u = 0.9862$, $w = 2.47\ 10^{-8}$. The minimum is for: $a = -0.3540$, $M(a) = 7917.36$ GeV.

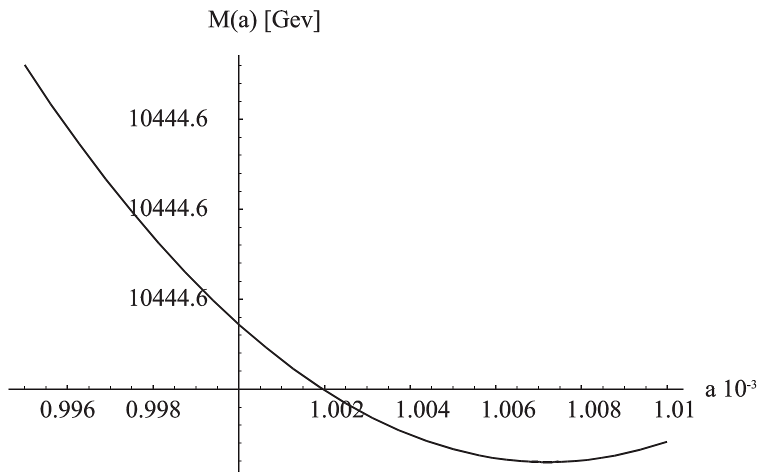

Figure 6: The dependence of the mass of the dilatonic sphaleron on a parameter $(a > 0)$, at the parameters: $r = 0.2958$, $u = 0.9862$, $w = 2.47\ 10^{-8}$.

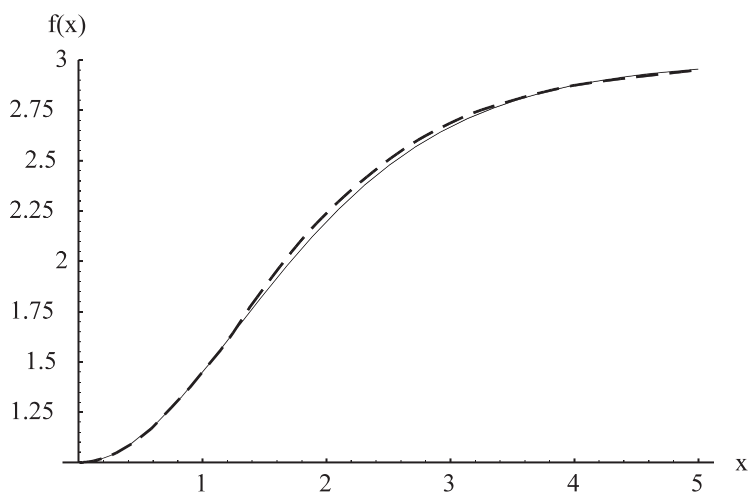

Figure 7: The dependence of the gauge field of the dilatonic sphaleron on x, at the parameters $r = 0.2950$, $u = 0.9862$, $a = -0.3540$, $w = 2.47\ 10^{-8}$.

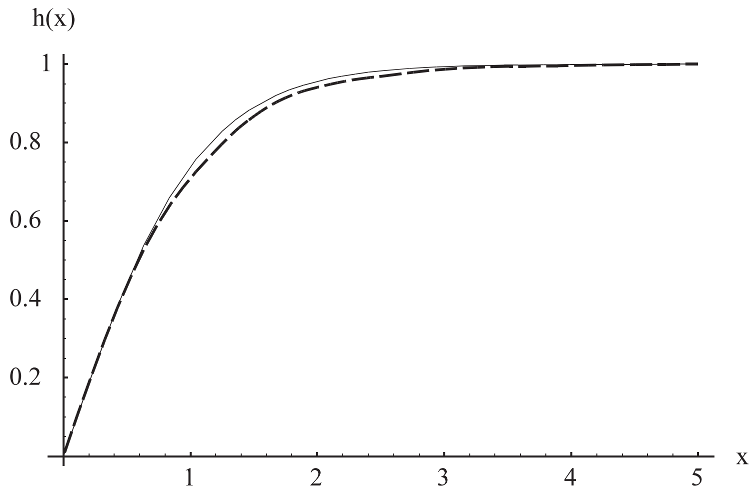

Figure 8: The dependence of the Higgs field of the dilatonic sphaleron on x, at the parameters $r = 0.2950$, $u = 0.9862$, $a = -0.3540$, $w = 2.47\ 10^{-8}$.

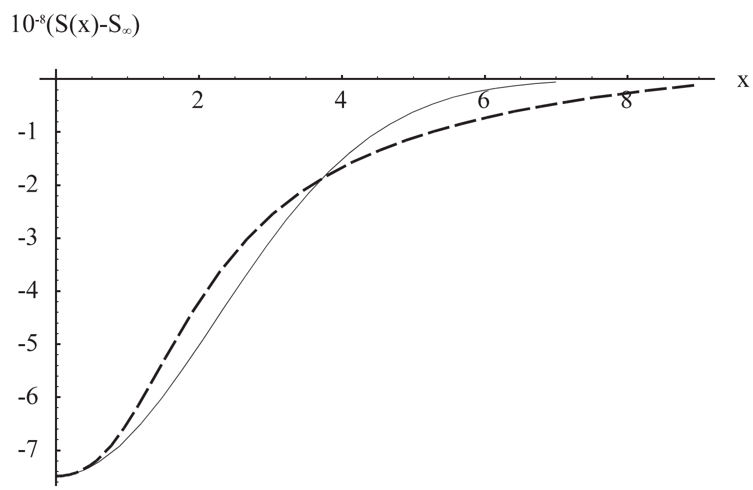

Figure 9: The dependence of the dilaton field on x, at the parameters $r = 0.2777$, $u = 0.9862$, $a = -0.3540$, $w = 2.47\ 10^{-8}$.